THREE-YEAR SURVEILLANCE FOR CESTODE INFECTIONS IN SHEEP DOGS IN CENTRAL UTAH[1]

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ABSTRACT.—During the summers of 1982, 1983, and 1984, 269 sheep dogs from an area endemic for hydatid disease were examined for cestodes (*Echinococcus granulosus* and *Taenia* spp.). Each dog was given an oral purge of arecoline hydrobromide and then following purgation received a subcutaneous injection of praziquantel (Droncit®). During the three-year study period, 205 dogs were examined one time only, 48 dogs were examined two of the three years, and 16 dogs were examined each of the three years (= 349 separate examinations). In 1982, 45 of 91 dogs examined (49.5%) harbored at least one species of cestode. Those data for 1983 and 1984 were 55 positive of 141 examined (39.0%) and 34 positive of 117 examined (29.1%), respectively. The marked drop in dogs infected during the second and third year of the study suggests that many sheep ranchers were implementing some of the control measures recommended for prevention of *E. granulosus* infections.

The numbers of separate purgations showing specific cestodes detected in all positive dogs (some dogs naturally with more than one species of cestode) were: *E. granulosus*, 16 (4.6%); *T. hydatigena*, 34 (9.7%); *T. ovis krabbei*, 46 (13.2%); *T. pisiformis*, 47 (13.5%); and *T. serialis*, 24 (6.9%).

As part of an over-all program designed to prevent and/or control the spread of hydatid disease in Utah and neighboring states (Andersen et al. 1983), a three-year surveillance study was planned to determine the prevalence of cestode infections in sheep dogs examined at the summer mountain grazing ranges in Sanpete County. Results of previous surveys had shown that the prevalence of *Echinococcus granulosus* tapeworms (the causative organism of hydatid disease in this region) fluctuated markedly, depending upon whether the majority of dogs examined in any one year were non-sheep dogs from rural communities or were dogs owned by sheepmen and used generally or exclusively in the sheep industry (Andersen et al. 1983). Many epidemiological determinants have been identified as important factors in the distribution and prevalence of *E. granulosus* in Utah, such as the use of local herders, the existence of community herds, the association of sheepmen from several counties on adjacent winter rangelands, and specific sheep-marketing practices (Crellin et al. 1982). Nevertheless, the role of the sheep dog as the principal definitive host of *E. granulosus* in this region remains as the single most important parameter for surveillance evaluation. The majority of sheep herds within Utah are located in Sanpete County, and almost all the surgical cases for removal of hydatid cysts have been people residing in that particular locality of the state (Crellin et al. 1982).

MATERIALS AND METHODS

The specific study area (Sanpete County involved in this project and its unique characteristics that make that region highly suitable as an endemic site for hydatid disease have been described earlier by Andersen et al (1983). The majority of summer grazing sites are located along or adjacent to the Skyline Drive, a dirt road that traverses north to south along the summit of the Manti–La Sal mountain range in that county. The mountains reach 3,600 m in elevation, are heavily vegetated with lush growths of forbs and grasses and afford numerous expanses for summer grazing of sheep. The general area is accessible mainly by the road along the summit, but it is intersected approximately every 10–20 km by roads ascending through canyons tha

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TABLE 1. Number of sheep dogs examined for cestodes in central Utah, 1982–1984.

Examinations		Years 1982	1983	1984
One examination (N = 205)		56	83	66
Two examinations (N = 48)		13 →	repeat	
			29 →	repeat
		6 →		repeat
Three examinations (N = 16)		16 →	repeat →	repeat
Total separate dogs = 269	Total examinations per year	= 91	141	117
		Total examinations = 349		

TABLE 2. Prevalence of cestode infections in sheep dogs examined, 1982–1984.

Year	Total examinations	Positive No. (%)	Negative No. (%)
1982	91	45 (49.5)	46 (50.5)
1983	141	55 (39.0)	86 (61.0)
1984	117	34 (29.1)	83 (70.9)
Total	349	134 (38.4)	215 (61.6)

connect to the communities on the valley floor, either to the west or east of the summit. Range sheep herds are routinely grazed in this mountain region during the summer months of May to October and then on the desert (100–200 km to the west) during the winter months (Crellin et al. 1982).

To contact as many sheep ranchers in the region as possible, a listing of all those having summer range allocations in the area specified was secured from the Utah Woolgrowers organization in Salt Lake City, Utah. Each owner was then sent a letter detailing the nature and intent of the project and some basic information on hydatid disease, with an emphasis on the role of sheep and sheep dogs in the life cycle of the causative parasite. All owners were encouraged to make necessary plans and arrangements to have their dogs examined and were informed that all examinations and all subsequent treatment of dogs would be done under the direction of licensed, practicing veterinarians. Furthermore, all services would be free. If anyone had any questions concerning the study, they were instructed to contact their own veterinarian or private physician for additional clarification.

Owing to the mountainous terrain where the grazing sites were located and because of unpredictable time restraints, no schedule could be prearranged when the examining team would be at a specific camp site. Nevertheless, in most cases owners were contacted at least one day in advance to encourage them to allow ample time for the clinic and to fast their dog for approximately 12 hr prior to the actual examination. Such a practice allowed for an evacuation of most of the dog's intestinal contents and made the subsequent purgation less severe.

At the time of the examination, the attendant veterinarian gave educational brochures to each owner and explained the process to be undertaken. Because approximately 10% of all dogs purged and examined at clinics in Utah over the past 12 years have shown some adverse reactions (spasms, labored breathing, incoordination, accelerated heartbeat, etc.), and since many of the highly trained sheep dogs were considered of relatively high monetary value, a release of responsibility form was signed by each owner before his dog could be examined. Also, a questionnaire was filled out identifying the owner's name and address, the number of sheep in each herd, and the name, breed, sex, and age of each dog to be examined. Each owner and each dog were given identification numbers to be used in all subsequent identifications and statistical tabulations.

Each dog was individually tethered with a collar choke chain and given an oral dose of 1.5% arecoline hydrobromide (3 mg/kg of body weight) to induce purging. One or two additional doses were given if no response occurred within an approximate 20–30

TABLE 3. Prevalence of specific cestodes in sheep dogs examined, 1982–1984.

	Neg.	*E. g.*	*T. h.*	*T.o.k.*	*T. p.*	*T. s.*
Year	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
1982 (N = 91)	46 (50.5)	10 (11.0)	15 (16.5)	13 (14.3)	22 (24.2)	5 (5.5)
1983 (N = 141)	86 (61.0)	3 (2.1)	8 (5.7)	21 (14.9)	17 (12.1)	13 (9.2)
1984 (N = 117)	83 (70.9)	3 (2.6)	11 (9.4)	12 (10.2)	8 (6.8)	6 (5.1)
Total (N = 349)	215 (61.6)	16 (4.6)	34 (9.7)	46 (13.2)	47 (13.5)	24 (6.9)

Legend:
Neg. = negative
E.g. = *Echinococcus granulosus*
T.h. = *Taenia hydatigena*
T.o.k. = *Taenia ovis krabbei*
T.p. = *Taenia pisiformis*
T.s. = *Taenia serialis*

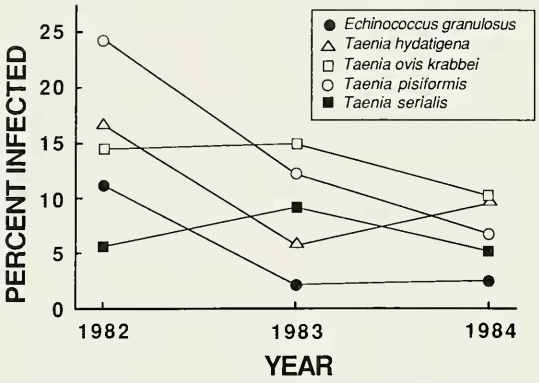

Fig. 1. Prevalence of cestodes in sheep dogs from central Utah, 1982–1984.

minute period following the initial dose. After a purge occurred, any large tapeworms present were carefully collected from the ground and placed into bottles containing 10% formalin. Also, any clear mucoid portion of the purge that might contain the small *E. granulosus* tapeworms was carefully placed in the same bottle, which was then labeled with all pertinent information and stored for laboratory examination. After purgation, each dog was given a subcutaneous injection of praziquantel (Droncit®; 5 mg/kg of body weight), a drug known to be highly effective in the removal of *E. granulosus* tapeworms (Andersen et al. 1978, 1979).

All samples were taken to the Parasitology Laboratory at Brigham Young University for examination of the collected material. The larger taeniids were transferred to new containers and then shipped to Kansas City, Missouri, where one of us (LAJ) identified the worms to species. The remaining fluid in each original sample bottle was divided into two equal portions and each part examined with a variable 7X-30X stereozoom microscope by a different investigator to detect the small *E. granulosus* tapeworms that might be present.

After the examinations and identifications were completed for each year of study, each dog owner was sent a letter detailing the results for each of his dogs and, when tapeworms were found, was also given an indication as to the most likely food item his dog had eaten to acquire such a tapeworm (e.g., sheep carcass, deer, rabbit, etc.). All data collected for each owner and each dog were entered onto tabular sheets designed for the project and then transferred to computer tapes. All categorization and tabulation of data were done on the Research VAX computer at BYU with the aid of Statistical Analysis Systems (SAS) programs. Analyses or statistical associations of specific cestode infections were tested for (1) effect of breed, sex, age of sheep dog, and number of sheep in individual herds (2) occurrence in dogs owned by individuals who submitted animals for an examination either two or three years of the three-year study period; and (3) coexistence within all sheep dogs examined during the entire program.

RESULTS

During the three-year study period, 269 separate sheep dogs were examined a total o

TABLE 4. Breed and sex of sheep dogs examined for cestodes, 1982–1984.

Breed	Sex		All dogs examined		Infected dogs	
	Male	Female	Number	Percent	Number	Percent
Australian Shepherd	4	6	10	2.9	5	3.7
Australian Shepherd cross	5	4	9	2.6	2	1.5
Border Collie	39	11	50	14.3	26	19.4
Border Collie cross	7	2	9	2.6	4	3.0
Blue Heeler	3	1	4	1.1	2	1.5
Blue Heeler cross	2	0	2	.6	1	.7
Collie	61	35	96	27.5	36	26.9
Collie cross	108	45	153	43.8	54	40.3
Dachshund cross	0	2	2	.6	0	0
German Shepherd	1	0	1	.3	0	0
German Shepherd cross	2	0	2	.6	1	.7
Kelpie	2	5	7	2.0	3	2.2
Poodle cross	3	0	3	.9	0	0
Terrier cross	0	1	1	.3	0	0
Total	237	112	349	100.0	134	100.0

TABLE 5. Age of sheep dogs examined for cestodes, 1982–1984.

Age of dog when examined	Number of separate examinations			Total examinations	Number of dogs infected	Percent of dogs infected
	1982	1983	1984			
0.5	10	27	26	63	14	22.2
1	19	21	17	57	22	38.6
2	16	31	19	66	32	48.5
3	12	18	16	46	20	43.5
4	9	10	10	29	10	34.5
5	4	10	8	22	10	45.4
6	3	6	6	15	8	53.0
7	5	4	2	11	5	45.4
8	4	3	3	10	4	40.0
9	3	2	2	7	2	28.6
10	4	3	5	12	3	25.0
11	1	2	2	5	3	60.0
12	0	3	0	3	0	0.0
13	0	0	1	1	1	100.0
15	1	1	0	2	0	0.0
Total	91	141	117	349	134	38.4

349 times; 205 dogs were examined only once, 48 dogs were examined two of the three years, and only 16 dogs were examined each of the three years (Table 1). Dogs were examined from 49 different owners, who had an average of 1,269 sheep each.

Tables 2 and 3 give various statistics as to the cestode infection levels identified within the dog population. Overall, 134 of 349 examinations (38.4%) showed at least one species of cestode present, whereas 215 examinations (61.6%) were negative. The level of infection in all examinations over the three-year period decreased from 49.5% in 1982 to 39.0% in 1983 to 29.1% in 1984 (Table 2). The infection levels for specific cestodes found over the three-year periods were: *Echinococcus granulosus*, 16 of 349 positive, 4.6%; *Taenia hydatigena*, 34 positive, 9.7%; *T. ovis krabbei*, 46 positive, 13.2%; *T. pisiformis*, 47 positive, 13.5%; and *T. serialis*, 24 positive, 6.9%. Specifically, the level of infection of *E. granulosus* dropped from 10 of 91 dogs positive (11.0%) in 1982 to 3 of 141 positive (2.1%) in 1983 and then rose slightly to 3 of 117 positive (2.6%) in 1984 (Table 3). The prevalence of

TABLE 6. Relative decline in cestode infections in sheep dogs examined, 1982–1984.

Cestode	Number of infections[1] 1982	1983	1984	Total	Gamma statistic	Standard error
Echinococcus granulosus	10	3	3	16	−0.522*	0.006
Taenia hydatigena	15	8	11	34	−0.208	0.156
Taenia ovis krabbei	13	21	12	46	−0.122	0.281
Taenia pisiformis	22	17	8	47	−0.440*	0.118
Taenia serialis	5	13	6	24	−0.047	0.176
Total:	65	62	40	67 Summary:	−0.269	0.087

[1]Some dogs infected with more than one species of cestode.
*Statistically significant decrease (SAS program).

TABLE 7. Statistical associations (uncertainty coefficient; SPSSX) of specific cestode infections tested against breed, sex, age of sheep dog, and number of sheep in individual herds, 1982–1984.

Variable	Cestode	Uncertainty coefficient*	Standard error
Breed	*Echinococcus granulosus*	0.074	0.046
	Taenia hydatigena	0.055	0.031
	Taenia ovis krabbei	0.057	0.022
	Taenia pisiformis	0.042	0.016
	Taenia serialis	0.042	0.017
	Summary	0.029	0.013
Sex	*Echinococcus granulosus*	0.012	0.018
	Taenia hydatigena	0.006	0.010
	Taenia ovis krabbei	0.021	0.018
	Taenia pisiformis	0.001	0.006
	Taenia serialis	0.002	0.014
	Summary	0.003	0.004
Age	*Echinococcus granulosus*	0.164	0.046
	Taenia hydatigena	0.084	0.038
	Taenia ovis krabbei	0.077	0.032
	Taenia pisiformis	0.061	0.024
	Taenia serialis	0.061	0.028
	Summary	0.047	0.016
Number of Sheep	*Echinococcus granulosus*	0.141	0.049
	Taenia hydatigena	0.111	0.036
	Taenia ovis krabbei	0.143	0.028
	Taenia pisiformis	0.047	0.022
	Taenia serialis	0.092	0.019
	Summary	0.066	0.022

*Uncertainty coefficient values represent the reduction in uncertainty (1 to 0) in predicting the specific cestode infection when the specific test variable (i.e., breed, sex, age, or number of sheep) is known. All values are extremely low (i.e., indicate poor predictive capability).

infection for each specific cestode detected over the three-year study period is depicted in Figure 1.

The dog population surveyed could further be categorized into 14 different breeds (Table 4) and into 237 male and 112 female dogs. The most popular breeds examined were Border Collie (14.3%), Collie (27.5%), and Collie cross (43.8%). The age of the dogs was categorized into 15 age groups between 0.5 and 15 years of age (Table 5), with 66% of all examinations being done on dogs 3 years of age or less.

The age group categorization of dogs infected with *E. granulosus* showed that of 16 total infections over the three-year period, 3 each were identified in dogs one, two or three years of age; 2 infections in four-year-old dogs, four infections in six-year-old dogs, and one infection in an eight-year-old animal.

Statistical analyses of the trends in cestode infections over the three-year study period showed an over-all decrease (SAS; summary gamma statistic of −0.269), with individual decreases for all parasite categories. The greatest single decline in any species was for *E. granulosus* (gamma statistic of −0.522; Table 6). Additional statistical analysis showed that there were no significant correla-

TABLE 8. Statistical association (Wilcoxon Test) for cestode infections in sheep dogs of owners who submitted dogs for examination two of the three years of the study, 1982–1984.

Cestode	Number of owners[1]	Number of dogs examined		P value
		1st exam	2nd exam	
Echinococcus granulosus	7	10	1	0.036*
Taenia hydatigena	10	15	3	0.012*
Taenia ovis krabbei	11	14	7	0.036*
Taenia pisiformis	17	24	4	0.000*
Taenia serialis	5	6	2	0.109

[1]Owners identified in this table are those individuals who had dogs infected with specific tapeworms at an initial examination (either in 1982 or 1983) and then submitted dogs for examination also in a subsequent year (either in 1983 or 1984).
*Significant decrease at < 0.05 level.

TABLE 9. Statistical association (Quade Test) for cestode infections in sheep dogs of owners who submitted dogs for examination each year of study, 1982–1984.

Cestode	Number of owners[1]	Number of dogs examined			Statistical significance*		
		1982	1983	1984	1982 vs. 1983	1982 vs. 1984	1983 vs. 1984
Echinococcus granulosus	5	8	0	1	yes	yes	no
Taenia hydatigena	7	10	2	3	yes	yes	no
Taenia ovis krabbei	10	13	9	6	no	no	no
Taenia pisiformis	11	18	10	4	yes	yes	yes
Taenia serialis	3	4	8	1	no	no	no

[1]Owners identified in this table are those individuals who had dogs infected with specific tapeworms at an initial examination in 1982 and then submitted dogs for examination also in 1983 and in 1984.
*Significant decrease at < 0.05 level.

TABLE 10. Statistical association (Fisher's Exact Test) on coexistence of specific cestodes in all sheep dogs examined, 1982–1984.

Cestode	*Taenia hydatigena*	*Taenia ovis krabbei*	*Taenia pisiformis*	*Taenia serialis*
Echinococcus granulosus	.002*	.244	.461	.302
Taenia hydatigena	—	.790	.793	.492
Taenia ovis krabbei	—	—	1.000	1.000
Taenia pisiformis	—	—	—	.029*

*Significant positive association at < 0.05 level.

tions in any of the cestode infection categories over the three-year study period for breed, sex, or age of sheep dogs involved, nor with number of sheep owned by any individual rancher (Table 7). For owners who submitted dogs for two annual examinations during the three-year study period there was a significant decrease in the infection levels noted for *E. granulosus*, *T. hydatigena*, *T. o. krabbei*, and *T. pisiformis* (at 0.05 level; Table 8). For owners who submitted dogs for examination all three years of the study, a significant decrease in infection levels was noted for two of the three years for *E. granulosus* and *T. hydatigena* and for all three years for *T. pisiformis* (at 0.05 level; Table 9). A significant positive association in the coexistence of specific cestodes detected in the study was seen for *E. granulosus* and *T. hydatigena* and for *T. pisiformis* and *T. serialis* (at 0.05 level; Table 10).

DISCUSSION

Epidemiological factors on hydatid disease for this region, such as anthelmintic treatment regimes used in the dogs, sheep management practices, owner awareness of the life cycle and transmission of hydatid tapeworms, and willingness of local individuals to cooperate with recommended preventive and control measures for the region, had been previously evaluated (Schantz and Andersen 1980, Condie et al. 1981, Crellin et al. 1982, Andersen et al. 1983), and were not assessed in the present study. However, from the data collected in this project, several conclusions or trends can be identified.

Although it was relatively easy to convince ranchers to have their dogs examined for one year of our study, it became increasingly difficult to obtain their cooperation in subsequent years. A total of 19 of 49 separate owners submitted dogs for examination in only one of three years of the study, 10 owners had dogs examined two of three years, and only 20 owners submitted dogs all three years. Consequently, even though we examined 269 different dogs during the project, 205 were tested only one year, 48 for two years, and only 16 were examined each year of the three-year period. Part of the apparent reason for a decrease in repeat examinations was the inconvenience for ranchers to submit their dogs for examination when they needed the dogs on a daily basis. Generally dogs subjected to the rather harsh purgation used in our study were unable to do hard work for several hours following the examination, and sheep ranchers rapidly became aware of this complication. Furthermore, the field team of veterinarians could not always arrive at the camp site on a planned schedule, could not always find the herd in a specific locale, and sometimes could not traverse the mountainous roads which were on occasion interspersed with drifted snow even into mid-August.

Another factor which complicated our being able to examine more dogs in subsequent years was the rather high turnover of dogs in this particular industry. The age profile categorization showed a marked cluster of dogs in the early age brackets, with 66% being three years of age or less. Reportedly, many dogs are lost or stray from the camp sites, some are purposefully destroyed when they do not prove to be easy to train, some are accidentally killed (e.g., being run over by owner's truck), and some cannot withstand the rigors of that type work for more than a few months at a time. Dogs in the latter category are routinely taken to the home residence of the owner and are allowed to recuperate for several weeks before being returned to the mountain rangeland. This decrease in dogs examined on a year-to-year basis naturally complicated our attempts to accurately identify the prevalence of cestodes in this population of animals and to properly evaluate our overall program. However, for those owners who did submit dogs for more than one year, there was a significant reduction in specific cestodes identified (Tables 8 and 9), which fact suggests that such owners were implementing recommended preventive and control measures in their overall sheep and dog management.

The study also showed that the same group of cestode species was identified in these sheep dogs for all three years, as shown in previous surveys (Andersen et al. 1973, Loveless et al. 1978, Jensen et al. 1982). Of particular importance was the fact that the greatest individual reduction in prevalence of any one species of cestode was observed for *E. granulosus* (gamma statistic of −0.522) and suggests that ranchers are indeed concerned about hydatid disease. The observed reduction in the prevalence of *T. hydatigena* (gamma = −0.208) should have paralleled more closely that of *E. granulosus*, since sheep serve as the principal intermediate host in the life cycle of both parasites. Jensen et al. (1982) found that 25 of 76 mule deer (32.9%) examined in central Utah harbored cysticerci of *T. hydatigena*, which fact could account for the availability of an additional source of infection (other than sheep) for dogs in that region. A consistent drop in the infection level also occurred for *T. pisiformis* (gamma = −0.440), where the numbers of infected dogs dropped from 22 in 1982 to 17 in 1983 to 8 in 1984. Such a decline could have been due to a drop in the rabbit (intermediate host) population, since rabbits go through regular fluctuations in numbers.

We did not see any statistical correlation in this study of specific cestode infections with breed, sex, and age of sheep dogs (Table 7). However, we did note a significant positive association on coexistence of *E. granulosus* and *T. hydatigena* and also of *T. pisiformis* and *T. serialis* (Table 10). The fact that the first two species of cestodes utilize sheep as principal intermediate hosts and that the second two use rabbits in that role corroborates the presumed dietary habits of the dogs harboring these cestodes and adds additional validation to the specific identification of the cestode reported over the three-year period.

With the mountainous terrain in this region and the large numbers of sheep present, it is unlikely that ranchers will ever be able to identify all sheep that die or are killed on the

grazing sites, nor will they be able to burn or bury all carcasses. However, our observations over the past several years have indicated that more ranchers are now using an increased amount of commercial food for their dogs rather than expecting them to scavenge for food, and that fewer sheep are now butchered for routine consumption by the herders than in former years. These practices would definitely reduce the availability of sheep viscera to sheep dogs at the camp site.

The probable advantage of using praziquantel in our program to treat all dogs in the region, irrespective of whether or not they proved to be infected with cestodes, is somewhat difficult to evaluate with the design of our project, and in particular with the lack of large numbers of repeat examinations. Inasmuch as the time required for adult worms to develop and become patent after cystic material is eaten by the dog is only 40–45 days (Rausch 1975), and since our program monitored the dogs only once per year, we are unable to substantiate the known efficacy of praziquantel as demonstrated in experimentally infected dogs (Andersen et al. 1978, 1979, Andrews et al. 1983). Nevertheless, our data show that there was a definite decline in the overall cestode infection level during the three-year study period, and a more frequent program of drug administration may be warranted. The use of praziquantel in our study was a clear signal to the owners and herders that chemotherapy must be incorporated into an overall program to prevent and control hydatid disease. Certainly the use of this particular drug would have had some contributory effect to the general downward trend in levels of cestode infection noted. Recent testing in our laboratory on the efficacy of a new paste formulation of praziquantel (Andersen et al. 1985) will be an additional benefit to the ranchers in this particular region, because they will soon be able to purchase and use that formulation rather than to rely on either tablet or injectable formulations. Tablets are frequently difficult to administer to certain unmanageable dogs, and injectable formulations require an assortment of needles and syringes or the services of an attendant veterinarian.

In spite of the difficulty in completing this particular surveillance project, the general attitude and cooperation of the owners and herders remained positive throughout. This same attribute has been evident from the very beginning of the hydatid disease control program in Sanpete County in 1971 and is undoubtedly the most important factor in whatever level of success the program has achieved. Inasmuch as the control program we have attempted to implement has been an entirely voluntary campaign, it has been essential that all measures advocated or undertaken be promoted in a cooperative and friendly manner. Many local individuals such as community and church leaders, educational administrators and teachers, public health workers, and local veterinarians and physicians have all contributed markedly to the success of the program. The incorporation of a filmstrip and coloring books on hydatid disease into the school curricula has definitely enhanced the educational aspect of the campaign (Crellin et al. 1982, Andersen et al. 1983). However, since the last surgical case for removal of hydatid cysts from an individual in Sanpete County occurred in 1979 (Crellin et al. 1982), it is important the complacency during an era of diminished public health emphasis not be allowed to occur. In 1971, 20%–25% of the dogs in several communities were infected with *E. granulosus* (Andersen et al. 1973), whereas it is now virtually impossible to find infected dogs from these same communities. Also, in 1971 approximately 10% of all sheep slaughtered at local abattoirs in central Utah had hydatid cysts (Andersen and Wallentine 1976), whereas 14 years later the number of sheep reported to have hydatid cysts is well below 1% of those slaughtered, and only rarely is it possible to collect hydatid cysts from abattoirs in this region. In 1984 only three dogs infected with *E. granulosus* were identified along the Skyline Drive, yet one of the dogs had the heaviest natural infection seen to date in this county. This dog could well have been a source of infection for at least several sheep grazing in that herd, which in five to seven years could be the potential source for continued transmission to other dogs. If such a focus of infection is perpetuated, the chance for eventual human cases originating from any one dog source would be greatly increased. Thus, the project now terminates with a possible "tip of the iceberg" still evident.

It now seems that most of the individuals living in Sanpete County have had ample opportunity to become educated about hydatid disease and the distinct characteristics that allowed the disease to become endemic in that region. Whether or not a concerted effort will continue by both individuals and community leaders in attempting to implement recommended preventive and control measures for hydatid disease in central Utah remains to be seen. Hydatid disease has been controlled or eradicated completely in parts of the world such as Iceland and on the Island of Cyprus, but extensive efforts to eradicate the disease elsewhere, such as in an endemic site in New Zealand, have not succeeded entirely (Gemmell 1979). Many of the unique characteristics and epidemiological determinants which were identified for Sanpete County (Crellin et al. 1982) still exist. The only major factor that has changed through time has been the increase in public awareness and basic knowledge on the life cycle of the causative parasite. It is hoped management practices for both dog and sheep populations in Sanpete County will be modified sufficiently as to indeed decrease the potential for human cases in the future.

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